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LIFE HISTORY OF *EUTRETA SIMPLEX* THOMAS ON *ARTEMISIA LUDOVICIANA* NUTTALL IN SOUTHERN CALIFORNIA (DIPTERA: TEPHRITIDAE)

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Abstract.—*Eutreta simplex* Thomas is univoltine on *Artemisia ludoviciana* Nuttall (Asteraceae), its only known host plant reported here for the first time. Eggs are inserted in terminal buds of young emerging shoots in the fall by the long lived females that emerged from galls late during the preceding spring. The second instars overwinter. Shoot, gall, and larval growth all resume early in the next spring. Galls are described in detail and pictured. Pupation occurs in the gall. Adults emerged from puparia after about three weeks during early July. Females convert their fat body tissues to yolk, but postpone oviposition until fall; moreover, they apparently can resorb these ovarian eggs, as a means of increasing fecundity and longevity.

Key Words.—Insecta, *Eutreta, Artemisia,* gall, life history, ovisorption

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My discovery of a somewhat accessible field population as well as the host plant of the heretofore little known, gall-forming fruit fly, *Eutreta simplex* Thomas (Diperta: Tephritidae), allowed me to study those aspects of its life history reported herein. The conduct of this field study and the interpretation of my findings on this still rare and elusive tephritid were greatly aided by my concurrent, more extensive field study of *E. diana* (Osten Sacken), reported separately (Goeden in press).

Taxonomy.—Thomas (1914) described *E. simplex* from a single female. The adults were illustrated and the male was described, again from a single specimen by Stoltzfus (1977).

Distribution, Hosts and Study Sites.—The North American distribution of *E. simplex* as recorded by Stoltzfus (1977) consists of two sweep records, one for the holotype female from 2440 m at Sunset, Colorado, 19 Jul 1903, and the other for a male and female from Big Meadow (probably on San Gorgonio Mountain, San Bernardino National Forest), SW San Bernardino Co., California, 8 Jul 1950. A female swept in Yosemite National Park in central California in 1940 by E. E. Kenage was identified for the U.S. National Museum in 1978 by F. L. Blanc.

The three principal study areas in 1987 and 1988 where I collected galls on *Artemisia ludoviciana* Nuttall (Asteraceae) from which I reared *E. simplex* adults included: Near the summit (2330 m), at Santa Rosa Spring, and on the southernmost point along the truck trail (2110 m) on Santa Rosa Mountain of San Bernardino National Forest, Riverside Co. Collections were also made at Coxey Meadow (1770 m), San Bernardino Mts., San Bernardino National Forest, San Bernardino Co., 26 Apr 1988.

Wasbauer (1972) and Stoltzfus (1977) listed no host information for *E. simplex.* Whether this tephritid is monophagous on *A. ludoviciana* (which also occurs in Colorado: Munz & Keck 1959), or forms galls on one or more other species of *Artemisia* (like *E. diana*: Fronk et al. 1964, Stoltzfus 1977, Benbow & Foster 1982, Goeden in press), is unknown.

Egg.—No intact or newly hatched egg of *E. simplex* was found in nature; however, like the egg of *E. diana,* it probably is inserted for most of its length singly into a bud (Goeden in press). The terminal buds of succulent young shoots formed in the fall, and arising from underground rhizomes (Fig. 1a), are the probable oviposition sites of *E. simplex.* Only one empty, apparently infertile egg was recovered from this position following week-long cagings of six mature laboratory-reared females with field-collected bouquets of these young shoots; the origin of this egg was uncertain. No eggs or newly hatched first instars were dissected from another 21 of these young shoots collected on 3 Nov 1988 from the same immediate areas at Santa Rosa Springs where galls were harvested earlier in the year.

Twenty eggs were dissected from a newly dead, 115 day old, laboratory-reared female (Fig. 1b). Like those of *E. diana,* these ova were fusiform, smooth, white, rounded at both ends, with a peg-like 0.03 mm pedicel at the cephalic end. They averaged 0.70 ± 0.006 mm ($\bar{x}$ ± SE) long and 0.25 ± 0.003 mm wide, slightly longer on average but with shorter pedicels than those of *E. diana* (Goeden in press).

Larva.—Despite repeated searches of specific areas previously yielding mid- to full-size galls, no immature gall was found on current season shoots in October and November, 1987 and 1988. The herbaceous galls of *E. simplex* on *A. ludoviciana* were observed to persist for at least six months after the adults had emerged, but most decayed or became buried by the second year; moreover, each emergent shoot is galled only once. Nevertheless, collection of several half-grown, overwintered galls containing second instars (May 1987 and 1988, Santa Rosa Mountain, Fig. 1c) strongly indicates this is the overwintering stage in southern California, as for *E. diana* (Goeden in press).

The fully developed, mature monothalmous galls of *E. simplex* consist of shortened and thickened terminals of sessile or short-stalked vegetative shoots formed at or just above the litter or soil surface (Fig. 1d). Externally, they are subovoidal, smooth, grey-green tomentose, and bear sessile leaves with expanded, transversely oriented, fish scale-like leaf bases. The leaf blades elongate at the gall apices to form characteristic, flattened rosettes 2–6 cm in diameter (Fig. 1e). The lengths and widths of 38 galls (collected on Santa Rosa Mountain and containing fully grown larvae or puparia, Fig. 1f, 1g) averaged 12.0 ± 0.4 (8–20) mm and 9.0 ± 0.2 (6–11) mm, respectively, after leaves were removed. The largely buried pedicels measured up to 7.6 cm in length between gall bases and their juncture with the rhizome (Figs. 1f, 1g). The central feeding chambers were clavoidal, open, rounded basally, narrowing apically, and measured 7.0 ± 0.3 (6–9) mm long and 3.0 ± 0.1 (2–4) mm wide ($n = 17$). The walls of the galls were pitted and covered with frass from larval feeding (Fig. 1f). The walls of mature galls were thickest basally (4–7 mm), thinner laterally (2–3 mm), and thinnest apically (<1 mm) at the point of exit for the adult (Figs. 1f, 1g).

Galls were found singly or in small groups of up to three beneath conifers on steep (45°), shaded, north-facing slopes in thick litter (upper site, Santa Rosa Mountain, 1987). They were scarce at this location in 1988. The first galls found were on plants growing intermixed with *Eriogonum wrightii* Torrey ex Bentham in an open, south-facing, gently sloping area (lowest site, Santa Rosa Mountain, 1987). None were found there in 1988. Since *E. diana* galls on *A. tridentata* usually

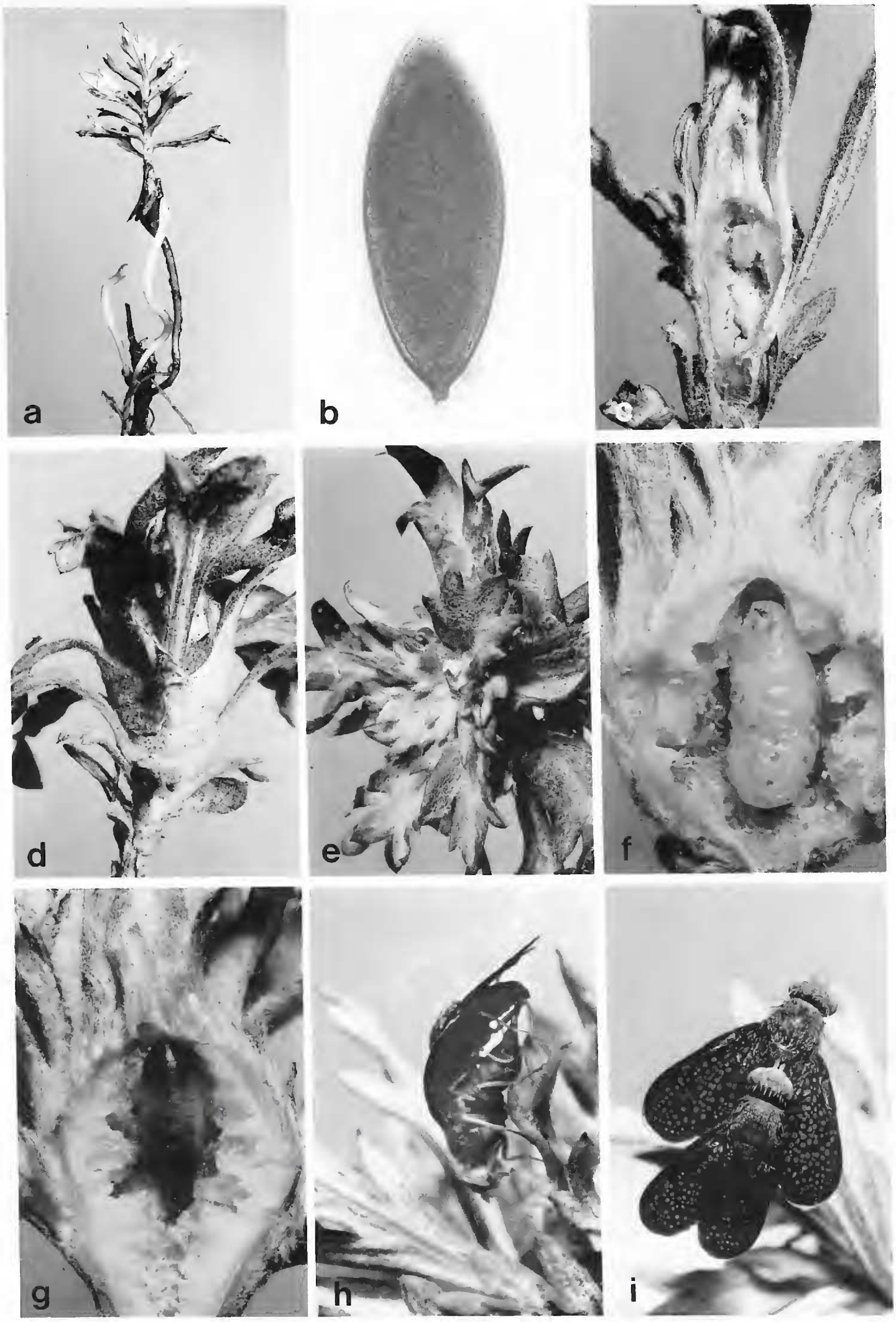

Figure 1. Life stages and galls of *Eutreta simplex* on *Artemisia ludoviciana*: (a) emergent and emerging vegetative shoots (1×); (b) photomicrograph of an unresorbed ovum (~ 100×); (c) overwintered second instar in gall (3.5×); (d) lateral view of mature gall (2×); (e) view of mature gall from above (1.5×); (f) saggital view of mature gall containing full-grown third instar (5.5×); (g) puparium in mature gall (4.4×); (h) mating adults, lateral view (4.7×); (i) mating adults, dorsal view (4.6×).

were located in drainages or riparian habitats (Goeden in press), I searched for galls at Santa Rosa Springs; most galls were found there in 1988 on plants growing on steep, moist, north-facing slopes beneath conifers.

Pupa.—The puparia (Fig. 1g) are formed with their anterior ends at or within the central, apical meristem. This usually is destroyed by larval feeding or adult emergence. The puparia are smooth, ellipsoidal, bluntly rounded posteriorly, and slightly more tapered anteriorly. They are translucent mustard-yellow at first but later turn dark orcherous brown at both ends. Puparia (n = 21) averaged 5.3 ± 0.08 (4.40–5.8) mm in length and 2.2 ± 0.04 (1.9–2.5) mm in maximal width. Pupation lasted about three weeks (27 ± 2° C, humidity chamber). One dead adult was observed that had become trapped in its gall upon emerging; it could not break through the tissue layer (left uneaten as a larva) at the gall apex. Galled shoots usually did not elongate apically after adult emergence, although if the larva within a gall died the terminal bud growth resumed forming a more elongate, narrower, fusiform gall. The shapes of *E. diana* galls on *A. tridentata* were similarly influenced by larval mortality and terminal bud reactivation (Goeden in press).

Adult.—No adults of *E. simplex* were found. Ten males and 13 females were reared from larvae and puparia dissected from galls collected in 1988, emerging during early July. The four galls collected at Coxey Meadow in late April (same year) yielded three females emerging in late May.

The adults were caged separately in screened-topped, clear-plastic, 850-ml cages supplied with a water-wick and honey to study longevity. They remained relatively inactive when isolated, usually resting on the side of the cage facing laboratory windows. Adult males lived 51–121 days ($\bar{x}$ = 85), and females (n = 11) lived 26–128 days ($\bar{x}$ = 83). Dissections indicated females were sexually immature at emergence, but (like males) had substantial fat tissue. In females the fat bodies subsequently were sequestered for yolk in ova (Fig. 1b).

Mating occurred readily without elaborate courtship behavior when surviving males and females were caged together in pairs about six weeks after emergence. During premating behavior, flies faced each other at a distance of 1.5–2.0 cm and slowly, alternately, waved their wings. The male then climbed atop the female from the rear. While in copula the male was largely off the substrate (Fig. 1h), except for his hind tarsi, positioned above the posterior of the thorax and abdomen of the female. His wings were held motionless, straight backward, overlapping, slightly parted, and flat upon his dorsum (Fig. 1i). The male's mouthparts touched the female's abdominal dorsum anteriorly, as both sexes pumped their mouthparts rhythmically. The female's wings were held perpendicularly and angled at 45° from the body (Fig. 1i). The male's foretarsi grasped the female's abdomen anterolaterally, his mesotarsi grasped her abdomen mid-laterally, while his metatarsi either intermittently stroked her oviscape, held it posteriorly or rested on the substrate. Matings observed in cages (n = 5) were protracted (3.5–4 h), usually beginning in the afternoon and ending at dusk (19:00). Twice matings were extended under artificial light for 6 and 9 h. Stoltzfus (1977) observed a caged pair of *E. caliptera* (Say) that remained in copula for about 4 h. Whether copulations of such duration normally occur is questionable. One male *E. simplex* died shortly after two protracted copulations on successive days. Stoltzfus (1977), however, reported that a pair of *E. caliptera* copulated on each of seven successive days!

Ovaries of four females that lived 115, 116, 127, and 128 days were found to

contain 66, 66, 58, and 48 full sized ova. The female that lived 127 days contained white, intact, unresorbed ova, but the other three females also contained varying proportions of nonwhite translucent ova whose contents had been partly resorbed. Ovisorption has long been known in parasitic Hymenoptera as an adaptation for extending the fecundity and longevity of synoovigenic females (c.f., Flanders 1935, Legner & Gerling 1967, Legner & Thompson 1977). Ovisorption in long-lived adult Tephritidae was first observed in *Trupanea conjuncta* (Adams) (Goeden 1987), and also occurs in long-lived adults of certain species of *Procecidochares* (unpublished data).

Seasonal History.—*Eutreta simplex* is univoltine on *A. ludoviciana* in southern California, as is *E. diana* on *A. tridentata* (Goeden in press); however, their seasonal histories show several major differences. Both species: overwinter as second instars in small, undeveloped bud galls; complete larval and gall development once vegetative growth resumes in the spring; pupariate in their galls; and emerge as sexually immature adults. However, *E. diana* adults mature, mate, and begin oviposition within three weeks. The larvae pass the summer and fall in diapause as first instars, and molt to the second instar just before winter begins. In contrast, *E. simplex* adults are long-lived and postpone their oviposition until fall. *Eutreta diana* on *A. filifolia* Torrey, another herbaceous host, displays a different seasonal history in Texas involving fall-emerging adults and overwintering eggs, but no summer and fall adult aestivation or larval diapause (Benbow & Foster 1982).

Natural Enemies.—No parasitoids and only one parasite exuvium were recovered from dissected galls or puparia of *E. simplex.* In contrast *E. diana* has a well-developed complex of natural enemies (Fronk et al. 1964, Benbow & Foster 1982, Goeden in press). Thirty-two galls were collected at the highest study area on Santa Rosa Mountain on 21 Oct 1987. Upon dissection: 19 contained empty puparia indicative of fly emergence; eight had apical openings but were empty, indicating predation; three were intact and small, containing carcasses of larvae that died of unknown causes; one intact gall contained the dead adult that failed to emerge; and only one had an exit hole and contained a larval carcass and parasitoid exuvium. No symptoms of bird predation or gall inquilines were observed with *E. simplex,* as for galls of *E. diana* on *A. tridentata* (Goeden in press).

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